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Barriers to climate change adaptation in the Australian construction industry – Impetus for regulatory reform

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ABSTRACT

It is increasingly recognised that the risks associated with climate change must be addressed through both mitigation and adaptation. Buildings are vulnerable to climate change risk and are also the source of a significant proportion of greenhouse gas emissions which contribute to climate change. The construction industry has significant potential to facilitate adaptation through actions that both reduce its contribution to greenhouse gas emissions across the construction and building lifecycle, and through physical adaptation of buildings and settlements to withstand present and future changes. However, there is limited evidence of significant adaptive action to date, and little is known about existing barriers to adaptation actions in the construction industry. This research explores barriers to climate change adaptation in the Australian construction industry through qualitative interviews with twenty-one key stakeholders. The barriers identified included: the use of inconsistent and unclear language, limited regulation, perceived unaffordability of initiatives, lack of awareness of climate change, and lack of client demand to implement initiatives. Recommendations to facilitate strategies for adaptation to climate change in the construction industry are provided. These focus on the need to a) address climate change through regulatory reform, and b) address the structure of the construction industry and its interrelationship with other built environment professions and processes.

1. Introduction

The earth's natural environment has undergone a significant transformation over the past century, largely driven by human population growth, industrialisation and urbanisation. This transformation is well illustrated by urbanisation figures, where, in 1900 only fifteen per cent of the world's population lived in urban areas, increasing to fifty per cent by 2008, a figure that is anticipated to reach seventy percent by 2050 [1]. Urban areas, and 'built environments' more broadly, are a key source of environmental change that drives climate change. 'Built environment' is a term used to describe:

> "… the interdisciplinary field of study which addresses the design, construction, management and use of the human-made surroundings and their relationship to the human activities which take place within them over time." ([2] p.25)

The form of the built environment is the result of decisions made by actors in numerous disciplines, including spatial planning, architecture, construction and urban design. Climate change has implications across all disciplines that operate in the built environment, and on the life cycle of buildings. This paper focuses on one sector involved in the built environment; the construction industry, which is directly responsible for the construction of buildings and infrastructure. In 2010, buildings across the world were responsible for nineteen percent of all greenhouse gas emissions ([3] p.4), thus directly contributing to climate change.

Recent studies that consider buildings' scales and full lifecycles have aided the understanding of the full impact of buildings on climate change [4,5]. Additionally, it has been identified that existing buildings face risks of damage from the projected impacts of climate change [3,6], which is anticipated to make a significant proportion of existing building and infrastructure obsolete [2]. Importantly, the long life-cycle of buildings means that poor design and performance today is difficult to address through retrofitting, and will have a long-term impact [3]. Given these factors, it is imperative that mitigation and adaptation to climate change are integrated [7,8], and that both are factored into construction processes. Such actions would help achieve the international goal of limiting climate change risk through the *Paris Agreement* [9].

There is significant potential for buildings, and the construction

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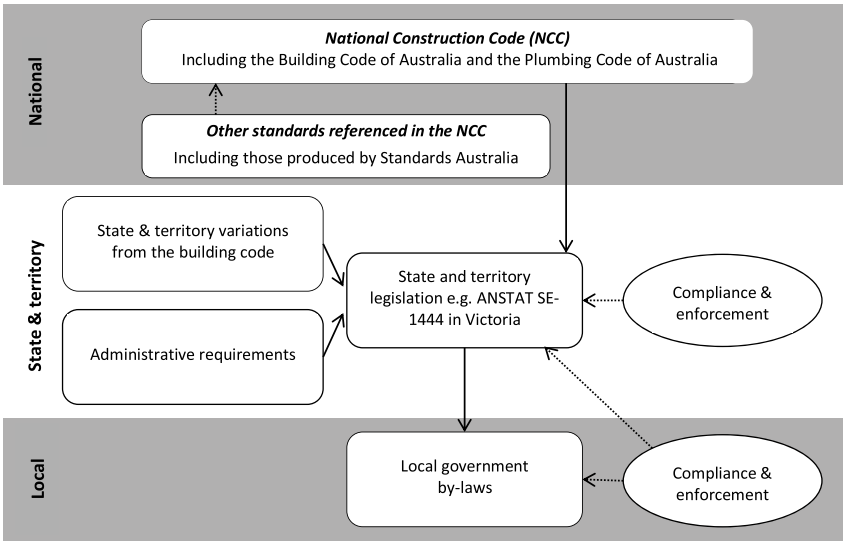
National
National Construction Code (NCC)
Including the Building Code of Australia and the Plumbing Code of Australia
Other standards referenced in the NCC
Including those produced by Standards Australia
State & territory
State & territory variations from the building code
Administrative requirements
State and territory legislation e.g. ANSTAT SE-1444 in Victoria
Compliance & enforcement
Local
Local government by-laws
Compliance & enforcement

Fig. 1. The structure of the regulatory framework that underpins mandatory standards [12,15].

industry more broadly, to facilitate both mitigation of climate change and adaptation to its impacts, as recognised in government reports at various scales [3,10–12]. Despite knowledge about climate change and the built environment, global greenhouse gas emissions from buildings continue to increase [13], and there is little evidence that the changes now occurring to building design and construction are sufficient to facilitate mitigation and adaptation strategies [3].

The aim of this paper is to identify and explore barriers to climate change adaptation in the Australian construction industry. There has been limited research conducted to identify and address barriers to adaptation to climate change in the construction industry. Given the similarities between the Australian construction industry and many other developed nations, this research is likely to have relevance in other contexts. The paper begins by providing an overview of the Australian construction industry, climate change impacts and their implications for the construction industry, followed by a review of relevant literature addressing adaptation barriers and opportunities in the construction industry.

2. The Australian construction industry

The construction industry in Australia is defined as “those businesses mainly engaged in the construction of residential and non-residential buildings (including alterations and additions), engineering structures and related trades and services” ([14] para. 4). It is the fourth largest contributor to the Australian economy and employs more than 1 million people [14]. Governance of the sector occurs through the three tiers of government: federal, state or territory, and local. To provide context for the present study, an overview of building industry governance in Australia is provided.

2.1. Mandatory regulations and standards

Under the Australian Constitution, state and territory governments have primary responsibility for building regulation. This is overseen by the Australian Building Codes Board (ABCB) [15] – a standards-writing body of the Council of Australian Governments – which establishes and maintains the national framework for building regulation, known as the National Construction Code (NCC) [16]. The NCC includes the Plumbing Code of Australia (PCA) and the Building Code of Australia (BCA). It is applied and enforced at state, territory and local levels. The NCC sets minimum requirements for the design, construction and performance of all on-site building and plumbing in a single code.

The BCA covers new commercial, residential and public buildings excluding ‘non-buildings’, i.e. engineering construction. These are also covered by Australian and International Standards and associated codes of practice that are regulated in a similar manner. The BCA requires those working in the industry to comply with national minimum standards and guidelines. It does this by either explicitly specifying the requirements; referring to standards typically maintained by Standards Australia [17], or to other organisations, some of which adopt European or international standards [18,19]. Under the NCC, there are also mandatory requirements for energy efficiency that are drawn from places other than Standards Australia. These require all new dwellings to meet a 6-star ‘Nationwide House Energy Rating Scheme’ (NatHERS) rating [20,21].

The NCC references about sixty standards in total including about fifty of the several thousand standards maintained by Standards Australia and made available for purchase by its wholly-owned subsidiary, SAI Global. An example is the Australian Standard, ‘ISO 9239.1’ for ‘assessing the wind-opposed burning behaviour and spread of flame of horizontally mounted flooring … ’. ISO 9239.1 is included in the BCA, and it is drawn directly from the ISO (International Organisation for Standardisation) Standard 9239–1:2002 [22]. Irrespective of their source, the reason for legislating adherence to standards is to provide certainty regarding a product's quality, its contribution to health and wellbeing and/or its sustainability.

The BCA is not itself legally binding. Rather, the NCC is given legal effect through state and territory building legislation and subordinate legislation (such as regulations) that ‘call up’ technical building requirements and standards contained in the NCC ([15]). It may also be overridden by, or subject to, State or Territory legislation. For example, in the state of Victoria, relevant statutes include the set of legislation, regulations and ministerial orders packaged by the ANSTAT Group as ‘Legislation Package SE-1444’ [23]. Relevant legislation typically also incorporates administrative provisions to facilitate the issuing of building permits and certificates to ensure compliance with the regulations. While states and territories have primary responsibility for enforcing building regulation in Australia, these responsibilities are typically further delegated to local governments through by-laws [12]. The way the regulatory framework operates in Australia is illustrated in Fig. 1.

2.2. Voluntary standards

In addition to the mandatory standards, there are several voluntary

standards by which buildings can become accredited. These are typically designed by industry groups or Non-Government Organisations with relevant expertise. They do not override the building code requirements, but are 'an additional process aimed at improving a proposal's performance beyond the minimum national standards' [24]. One of the best known of the voluntary standards is 'GreenStar'. It provides independent verification of the degree to which a building or development is sustainable as measured by its energy, water and materials use, its transport profile, its land use and ecology, emissions, indoor air quality, management and its innovation [25]. NABERS is another voluntary accreditation program managed nationally by the New South Wales (NSW) Office of Environment and Heritage. It uses third party accredited assessors to appraise the environmental performance of Australian buildings, tenancies and homes as measured by their energy efficiency, water usage, waste management and indoor environment quality [26]. Despite its origins as a voluntary standard, it has mandatory application in the property sector for buildings over 1000 square metres in size through the Mandatory Energy Commercial Disclosure Program (http://cbd.gov.au/).

Other accreditations are WELL, which rates buildings for their ability to provide a healthy and productive working environment as determined by their ability to efficiency provide thermal comfort [27] and BASIX (Building Sustainability Index), which 'aims to deliver equitable, effective water and greenhouse gas reductions across the NSW' [28]. Some local governments have incorporated rating and accreditation tools into urban planning application processes, effectively making them mandatory for some stakeholders. BASIX in NSW is one example, as is the Built Environment Sustainability Scorecard (BESS), an assessment tool created by the Council Alliance for a Sustainable Built Environment, a group of (currently) twenty-two Victorian local governments [29].

3. Climate change and its implications for the construction industry

The built environment is exposed to considerable uncertainty and vulnerability to climate change implications. The impacts of climate change will vary from location to location but could include [30,31]:

- increased extreme weather events (wind, rain, hail, heat)
- increasing variability and intensity of rainfall events
- potential for increased flooding
- longer and more frequent drought periods
- increased severe temperature durations
- sea level rise

All of these climatic changes, will have an impact on the construction industry, from the nature of the products they are constructing, to the processes used for construction. In addition to these implications, there will be indirect impacts, including the possibility of losses associated with operational aspects of the property like rent, or business income generation [32]; and consequential losses associated with lower investment, increased vacancy and depreciation, and loss of demand resulting in discounted sales prices, values and rent [33]. The implications of climate change for the construction sector are not often considered, as the constructors of buildings are often only involved for a short period of time; but what is constructed will need to weather the challenges of climate change for 50–100 years. Consequently, there is often a short-term focus from the construction sector, in relation to how they deal with weather. However, the implication of climate change for the construction sector have been identified to include [30]:

- increased risk of delays to construction
- increase risk of damage to property assets, buildings and construction equipment
- increase in weather related insurance and reinsurance costs

In order to address these potential impacts, Smith [30] outlines a range of adaptation strategies, including:

- build components off site (in warehouses)
- develop management plans for: hailstorms; cyclones; bushfires
- construct buildings on land several metres above sea level
- design, build and retrofit for: water efficiency; energy efficiency

It will be necessary for the construction industry to adapt to these challenges, however there is limited information available about adaptive actions than have been undertaken, and barriers to adaptation in the field. A review of existing literature is now provided.

4. Barriers to climate change adaptation in the construction industry

There is limited published research on barriers to climate change adaptation in the construction industry. A review of literature specifically on climate change adaptation in the construction industry identified barriers and enablers across built environment sectors including construction, building, coastal resource management, property, and social housing. Table 1 summarises the key barriers and opportunities for climate change adaptation in the construction industry identified in published literature.

The barriers identified were grouped into three broad categories: resource issues (e.g. lack of time, money and technological expertise), institutional (e.g. governance and policy) and psychosocial (e.g. cultural barriers, and industry perceptions of client and public opinion about climate change). The majority of research was empirical, using stakeholder surveys (e.g. Ref. [43]) and/or interviews [38]. One paper included analysis of public submissions to the Australian Productivity Commission's Inquiry into Barriers to Effective Climate Change Adaptation [35]. The location of the studies ranged from Europe to America and Australia, with the largest number of studies originating from the United Kingdom (UK).

The analysis established that a range of opportunities to facilitate climate change adaptation can be identified from these barriers, and the two concepts are interrelated. For example, the lack of policy and regulation to adequately address climate change has been identified as a barrier to climate change action in the Australian built environment context [35]. Yet, it has also been recognised that changes to regulation could provide an opportunity to address necessary climate change adaptation and mitigation measures [38]. Further, a recent review undertaken by the Australian Department of Climate Change and Energy Efficiency examined *The Role of Regulation in Facilitating or Constraining Adaptation to Climate Change for Australian Infrastructure* [11]. The report found that for the construction sector, current legislation provided barriers to adaptation, but concurrently, opportunities exist to use existing regulation frameworks to facilitate adaptation.

Various terms are used in the literature to describe opportunities for climate change adaptation: including 'enablers', 'facilitators' and 'drivers'. It was found that when studies identified opportunities for climate change adaptation, they tended to be largely based on secondary assessments of literature and practice [44,45], with some based on empirical evidence [43] or document analysis [41]. A range of opportunities for climate change adaptation in the built environment sector was identified, from greater regulation and reform by government [41,43–45] to a facilitative organisational culture [46]. Additionally, the experience of climate change impacts, cost, and societal influence/pressure [41] was also found to influence action. These opportunities are included in Table 1.

This review indicates a need for further research on the barriers to climate change adaptation in the construction sector and in the Australian context in particular.

Table 1
Barriers and *opportunities*[a] for climate change adaptation in the built environment.

Barrier	Study	Sector of study	Country	Context
RESOURCE ISSUES				
Lack of time/staff	[34]	- Coastal Resource Management (CRM)	- America	- Impacts ability to consider climate change impacts on activities. Prominence of near term issues, detracting from long term issues such as climate change.
Cost	[34]	- CRM	- America	- Lack of financial resources impacts ability to consider climate change impacts on activities.
	[35]	- Multi-sector	- Australia	- Lack of human and financial resources to address climate change.
	[36]	- Housing development	- Australia	- Not cost competitive to include adaptations when competitors are not doing so
	[37]	- Building	- UK	- Climate Change actions were associated with (perceived or real) costs – time and money.
	[38]	- Building	- UK	- Focus on reducing capital cost of works prevents consideration of longer term design alterations that deviate from minimum regulatory standards.
	[39]	- House building	- UK	- Lack of financial incentive to employ climate change technologies - Short term cost of technology falls to developer, but long-term cost saving falls to property owner.
	[40]	- Construction	- UK	- A fee structure based on the capital cost of a building incentivises the over-specification of systems, and thus poor climate change outcomes result. Creates disincentive to improve energy efficiency.
	[41]	- *Multi-sector*	- *UK*	- *Cost savings were identified as a driver for adaptation actions*
Technology/technological constraints	[34]	- CRM	- America	- Technical, or technology constraints
	[35]	- Multi-sector	- Australia	- Lack of data at local and regional scales; non-specific nature of information; uncertainty around information; lack of capacity to assess information.
INSTITUTIONAL				
Governance	[34]	- CRM	- America	- No requirement to consider future climate in decision making - Vested interest of key actors (e.g. private property owners) a barrier to future oriented collective action. - Imbalance in political power and other positioning.
	[35]	- Multi-sector	- Australia	- Conflicts between and within levels of government. Lack of leadership.
	[42]	- Social housing	- Netherlands	- Housing associations were of the opinion that the government and other external players (e.g. insurance/water authorities) acted as controllers/advisors rather than allies.
	[41]	- *Multi sector*	- *UK*	- *Risk management process in organisations were found to drive adaptation actions*
Policy	[35]	- Multi-sector	- Australia	- Inconsistency of policy across scales of government. Weak policy/regulation.
	[43]	- Property	- Australia	- Confusion over climate change policy was perceived to impede developer action on climate change.
	[41]	- *Multi sector*	- *UK*	- *Legislation – general and climate change specific – was found to be a driver of adaptation actions*
	[44]	- *Building*	- *Global*	- *Author opines that both regulations and market mechanisms can facilitate adaptation*
Industry	[40]	- Construction	- UK	- Linear design process; perverse incentives; reliance on cost-based competitive tendering
PSYCHO-SOCIAL				
Cultural issues	[35]	- Multi-sector	- Australia	- Lack of public understanding of climate change. - Cultural aversion to change.
	[41]	- *Multi-sector*	- *UK*	- *Societal pressure was found to be a driver of adaptation actions*
	[44]	- *Building*	- *Global*	- *Author opines that owner occupiers will be able to directly access information about the benefits of adaptation actions and implement them (as opposed to building/property managers)*
Perception of client attitudes	[37]	- Building industry	- UK	- Perception that clients are unwilling to spend additional money on sustainable low energy initiatives.
	[43]	- Property	- Australia	- Perception that a barrier to initiatives include developer disinterest in paying for green development.
	[34]	- CRM	- America	- Perceived lack of social acceptability of adaptation options.
Experience	[41]	- *Multi-sector*	- *UK*	- *Experience of climate change impacts was found to be a driver of adaptation actions*

[a] Opportunities shown in italics.

5. Research method

The aim of this paper is to identify and explore barriers to climate change adaptation in the Australian construction industry, and from these barriers, identify opportunities to facilitate adaptation. The research method designed to achieve these aims is described below.

5.1. Participants and their recruitment

Twenty-one interviews were undertaken with key actors in the Australian construction industry between February and June 2017. A common guide for sample size in qualitative research projects is 15 ± 10 [47, p.13], given the tendency of further interviews to provide no new information ('saturation') [47]. Qualitative studies with similar sample sizes have been previously published in this field [39,46]. Participants were purposively recruited across Australia's three construction sectors – residential, non-residential and engineering [14]. Participation was sought from construction managers and sustainability managers, in a range of construction firm sizes, and was by invitation only. Participants were based in capital cities of four of Australia's eight states and territories (Canberra 1; Sydney 7; Melbourne 12, Perth 1). This sampling strategy sought a diversity of views, given the qualitative nature of the research.

Three interviews were conducted via telephone, with the remaining eighteen conducted face-to-face, with a duration ranging from 17 min to 1 h. The interviews were digitally recorded subject to the participant's permission. One participant declined, thus hand-written notes were taken. Table 2 provides an overview of the participants, including the codes that will be used later in the paper to report the findings (in line with the project's research ethics protocol).

5.2. Interview design

An interview guide was developed to ensure consistency between interviewers (three). The interviews were designed to be semi-structured in nature, allowing interviewers to ask unscripted questions to further explore issues raised where appropriate, and to clarify responses. A range of questions about adaptation to climate change in the Australian construction industry was included. The introductory questions asked about the participant's background, and what they perceived to be the three main challenges facing the construction industry at present. Questions then addressed their preparedness to address climate change risks, along with their information use and needs, and perceptions of the main barriers to implementing adaptation to climate change. A series of short questions concluded the interview.

5.3. Data analysis

The digitally recorded interviews were transcribed then analysed using NVivo 11 [48]. The focus of the data analysis reported in this paper was the question related to barriers to implementing climate change. However, complete interviews were reviewed for the identification of barriers and opportunities mentioned in response to other questions. A three-stage process was followed for the analysis.

Firstly, each interview transcript was read while simultaneously listening to the corresponding digital recording. While doing so, the first stage of coding for the issues raised about barriers to climate change, was identified by assigning a 'node'. During the interview process respondents also commentated on factors that could provide opportunities for climate change adaptation. These were also coded, given their close relationship to barriers. Secondly, the data identified in each 'node' was further coded into sub categories, known as the process of 'coding-on' [49]. Thirdly, a second coder reviewed the coding undertaken at steps one and two. Where differences of opinion were discovered, these were discussed and a decision to either recode, code-on or keep the coding 'as is' was made. Coding was used by the researchers to understand the emphasis and dominance of issues raised by participants. In line with the intentions of qualitative research, this iterative review of content under codes served to verify [50] interpretations of data, rather than quantify content within codes. Statistical intercoder reliability testing was therefore not conducted, and is largely seen as inappropriate for qualitative research [50].

Table 3
Issues raised by interviewees as either 'barriers' or 'opportunities' to action on climate change adaptation in the Australian construction sector.

Factor	Number of interviewees	Number of times mentioned as:	
		Barrier	Opportunity
Language	11	24	11
Client demand	10	20	9
Affordability	10	15	11
The regulatory framework	10	11	12
Climate change awareness	10	17	5
Expertise	10	21	3
Uncertainty	9	16	1
Innovation	8	7	3
Information	6	6	6
Leadership	6	9	8
Market influence	6	3	3
Industry culture	5	7	2
Resource efficiency	5	0	10
Use post-construction	4	4	1
Research translation	2	2	1
Integration	1	1	0
Location	1	1	0

6. Results and discussion

Table 3 details the issues identified, and the number of times each issue was raised as a barrier and as an opportunity. In total sixteen factors were identified as barriers, and fifteen as opportunities. All except three of the factors were raised as both a barrier and opportunity. Notwithstanding the qualitative nature of this research, the purpose of presenting the data in Table 3 is to provide an overview of the breadth of the findings, and the dominant issues. Below we discuss the five most dominant issues raised.

6.1. Inconsistent or unclear language

The issue of 'language' was the most frequently mentioned factor impacting action to address climate change, mentioned about twice as

Table 2
Interview participants by category.

Sector/Respondent Type	Sustainability manager (SM)	Construction Manager (CM)	Industry Association (IA)	Total
Residential construction (RC)	3	3	1	**7**
Non-residential construction (NRC)	5	4	1	**10**
Engineering construction (EC)	3	0	1	**4**
Total	**11**	**7**	**3**	**21**

frequently in negative terms (i.e. to be a barrier) as it was in positive terms. It included several sub issues such as but not limited to: familiarity (or lack of it) with concepts such as 'convective heat,' or 'resilience', the marketability of climate change action, and the framing of ideas. Interviewees' comments revealed that language is strongly related to awareness and perception. An example is provided by one interviewee who explained that, when communicating with clients, framing actions in terms of 'green' benefits could cause them to preclude optional design modifications, which could have economic and health co-benefits. They remarked that how this was phrased to the client could have a different result, for example:.

> You can't call it sustainable energy, you can call it energy efficiency and you might get a hit. 'Good daylight, good air', you know; 'low VOCs [volatile organic compounds]' and all that sort of stuff. You can put it in that language, but the minute you tag it 'green' it's something that is "I don't have to have that, I'd rather have a pool". (NRC SM5)

One of the industry association representatives also identified this as a barrier, but stated that opportunities to implement action to address climate change were better realised if they spoke about,

> … these houses as being better, more comfortable and healthier … because people [are] kind of … over the 'environmentally friendly house'. (NRC IA1)

In addition to couching opportunities in terms which are less sensitive or political than 'climate change', or 'the environment', several interviewees thought that it was important to couch opportunities in terms of actions that were immediate, accessible and achievable. As one interviewee stated, 'I think a lot of times people hear 'climate change' and they turn off' (NRC SM1). More broadly, some interviewees spoke of a general lack of understanding of the issues surrounding climate change, and that in the context of inadequate skills within the industry (NRC CM3, RC IA1) the terminology that was being used had led to a lack of willingness to engage on the issues,

> I think the language; the terms *resilience* and *adaptation* and stuff is confusing. I've got a guy on my team who's … always pulling me up on the difference between adaptation and mitigation and that and I think, "oh God, we made it so damn complex". (NRC SM2)

This finding suggests that 'language' and how climate change is communicated can act as a barrier to action in relation to adaptation in the construction industry. Yet, closely related to the issues raised here is the perception that the public lacks understanding of climate change, and that there is a cultural aversion to change [35]. There are several implications of this finding, including the benefit of information sessions, both for the general public, and industry members to increase climate change literacy and understanding of impacts and benefits of initiatives. This includes all members of the construction industry, from design teams, through to sales and construction staff, given all of these were mentioned in interview discussions.

6.2. Limitations of the regulatory framework

The regulatory framework of the construction industry was a dominant theme. Overall the existing framework was acknowledged to be limiting the implementation of climate change action. Opportunities to address climate change through regulation were acknowledged. Interviewees acknowledged the value of regulations and codes (e.g. NCC) in providing certainty regarding the minimum standards and 'a level playing field' (RC SM2) to which all members of the industry must adhere. Without enforced minimum standards, many interviewees felt that quality would be worse than it is currently. For example, one interviewee spoke of action to address energy efficiency only being undertaken because of the existence of an enforced regulatory framework, 'A lot of [volume builders] only have externally sourced thermal performance assessors because it's compliance' (RC SM3). As another stated, regarding the certainty that enforced minimum standards provided,

> I personally don't like legislation but, at the same time I do … it helps give everybody a guideline. Everyone has good intentions but without a big formal legislation around it, everyone's just sort of making their way in the dark. (RC CM2)

While important for creating certainty (which has parallels to findings in the Australian water sector [51]), the regulatory framework was explicitly mentioned by ten interviewees as a barrier to the implementation of actions to address climate change, principally through the setting of standards that were in fact too low to make a meaningful contribution to either mitigation or adaptation. The inadequacy of current regulations is particularly well implied by the following quote where an industry association representative relays a recent discussion with one member,

> I spoke to [him] yesterday, and [he] has just finished a renovation, so he said, "It gave us the opportunity to insulate the rest of the house … so we talked about that with the client". That's great, that's what I want to see, but … most clients, most people aren't interested, they just want a house that meets regulations. (NRC IA1)

Another interviewee used the metaphor of a pyramid (Fig. 2) to explain that she felt that, in comparison to voluntary accreditation programs, regulations were not lifting the standard of the industry overall,

> … the green building ratings were dealing with the top, and NABERS was the top plus a bit, and the regulations were at the bottom. And, what we've perceived over the 12 years … is the pyramid's just become taller and taller and taller, and the bottom hasn't really lifted. (NRC SM5)

Echoing this sentiment, when asked if there was potential for the regulated standards for buildings to be increased, one interviewee replied, 'I think definitely, without a doubt in the world' (RC CM2). Another interviewee believed that the standards do not support the industry in its endeavours to be responsive to climate change. On the other hand, increasing mandatory standards would have the flow-on effect of encouraging innovation,

> In terms of legislative changes that affect the construction industry, [there is a] … lack of policies that would support what we're trying to do as an industry. (RC SM1)

This participant was from a large construction company which was innovative in its approach to environmental and sustainability aspects of projects, a position which was core to the organisation's values. Others spoke of their limited capacity and willingness to push clients to

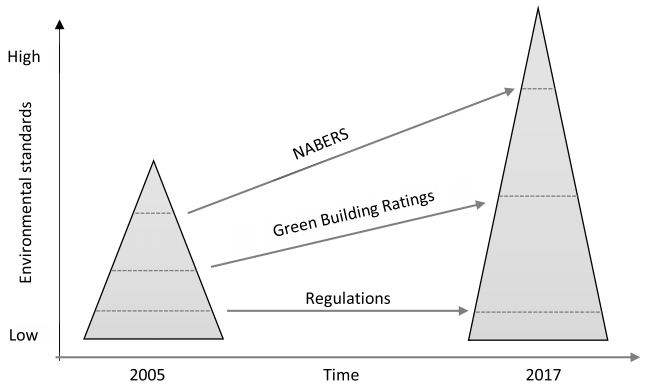

Fig. 2. The perceived change of Australia construction industry standards over time.

exceed the mandatory standards, stating that many in the industry do not see it as their obligation (NRC CM2). They did however acknowledge that they have a role to provide advice to the policymakers that review and update mandatory standards (NRC SM4).

Consistent with Moser and Luers [34] who found that California coastal managers deemed legislation to be inadequate for protecting communities against storm surge, the regulatory framework for building and construction in Australia was viewed by interviewees as significant for determining the extent to which climate change actions were implemented. Many interviewees felt that the regulatory framework, particularly the current mandatory standards, were a barrier to action. This has parallels to existing literature in the coastal resource management sector in the USA [34]. Reviewing both mandatory and voluntary standards to ensure climate change adaptation and mitigation is addressed presents an important opportunity for greater action to address climate change, also suggested as important in other built environment contexts [41,43].

6.3. Perceived unaffordability of climate change initiatives

Often, the cost of actions to address climate change was seen by interviewees as a barrier to action. Typically, interviewees felt that actions to address climate change were perceived by clients to be not worth the inevitable additional investment of time and money. Consequently, from the construction firms' perspective, because 'margins are falling' and there is 'much greater competition' between companies (EC SM1), there is a reluctance to suggest any innovation that could increase prices for clients. Under these circumstances the industry was seen to be 'stretched on resource' (NRC CM2) with one interviewee stating that the effect of this was that,

> If the market doesn't value that [additional] dollar, and our competitors aren't doing it, essentially they won't buy our house. (RC SM2)

Similarly, regarding the inevitable higher cost of products that had incorporated climate change adaptation or mitigation initiatives, another interviewee stated,

> There's just not enough 'free air' around that commercial activity to really give it … the attention it deserves. (NRC CM3)

Construction companies largely focus on the short-term activity of construction, and in most situations do not have the longer-term costs of building use and management to consider in their cost equations (public/private partnership is one exception to this). From a construction materials perspective, one interviewee described that an opportunity to compensate for the lack of an economic imperative was to coordinate companies to use their buying power to create economies of scale, for example,

> … a number of us contractors consistently stipulating it (i.e. higher environmental standards) within our purchasing requirements … that would actually make it viable for the industry. (EC SM2)

This demonstrates the capacity that many interviewees had to translate an identified barrier into an opportunity. In a similar vein, one interviewee stated that there was an opportunity for the broader industry to implement action to address climate change if the environmental impacts were factored into prices and into investments. He was optimistic that this was an emerging trend, stating for example that some influential leaders were:

'pushing the idea that really, we're not pricing climate change risk into asset values' … super funds and some of those groups will find [incorporating the economic cost of climate change into prices] hard to avoid … It's probably less than ten years from now. (RC CM5)

The issues raised here align with the regulatory issues discussed earlier – if regulation required these considerations to be made, a level playing field would be created for the cost implications of implementing such initiatives. The issue of minimising expenditure has also been identified as a barrier to adaptation in the construction industry in the UK [39,40].

6.4. Lack of climate change awareness

'Awareness' refers to both industry members' and the broader community's level of climate literacy [52], their opinions, and their willingness to be open to opportunities to respond. In most cases, lack of awareness and negative perception were a barrier. This also suggests that there is much work to be done to increase both community willingness and industry efficacy [53] to address climate change.

One interviewee mentioned that because climate change was slow in manifesting, 'most of the industry does not see it as their obligation' (NRC CM2). Potentially this is because they have not yet experienced any direct impacts of climate change – a phenomenon identified by Tompkins et al. [41] as a driver for adaptation actions in the UK built environment context. In response to the question about barriers that limited action to address climate change, another interviewee spoke of their perception that there is 'a prevailing (community) belief that climate change isn't human-caused' (NRC SM1) and one stated that this had the effect of lowering community priority for climate change action, and even if they did believe that it was real, of attitudes such as,

> "I don't care" and "it's not going to be in my lifetime, I don't want to know about it." (RC CM2)

This has parallels to research in the water industry which has shown the success of water demand management (water consumption decreases) and related initiatives (e.g. water efficiency aids implemented) in times of drought (greater awareness of water issues), when compared to regular conditions [54]. These results indicate that organisations in the construction industry were willing to take on initiatives that addressed climate change, but that there was a perception that there was very little community appetite for them. This suggests that with increased capacity to influence clients, the industry has the potential to be a leader for action on climate change in the wider community. One interviewee suggested that if there was more client demand for climate-sensitive projects, there was a very real capacity to shift the community's perception of the industry to one where,

> … people realise that we're contributing usefully … and it's not about a 'no' and a negative, it's about "is it going to actually be implementable and effective" and achieve your outcome, whatever your outcome is. (RC IA1)

These results are consistent with existing literature that finds that a lack of awareness of climate change in the construction sector [37,55] and the lack of awareness and acceptability in the general public [34,35] can act as a barrier to climate change adaptation.

6.5. Lack of client demand

As indicated in previous sections, several interviewees raised lack of client demand as a reason for poor uptake of climate change mitigation and adaptation strategies in the construction industry. Occasionally this was raised independently of any hypothesised reason. For example, as one interviewee stated regarding the residential sector, 'most of those guys I know (in residential) that are really into (green buildings) will say, "I'd love to do more, but most of my clients aren't interested." This interviewee went on to say,

> We've got big volume builders with … 60 or 70 percent of the market, building houses that people want … and most of those people (clients) aren't even asking that question. (NRC IA1)

The level of client demand for projects that respond to climate change was also shown to be related to the language that is used, to the state of the regulatory framework, the price that clients are willing to

pay, and to be strongly determined by clients' own awareness and perception of climate change as a risk. As an example of this, while the regulatory framework provided an element of certainty, it was seen by several interviewees to be reinforcing minimum standards thus having negligible effect to increase client-demand for higher quality products.

Similarly, some interviewees implied that language, and the way issues are framed has led to reduced client demand for action to address climate change. Occasionally however, the way issues were framed was seen as an opportunity to leverage increased client demand for climate change mitigating products,

> [If it's] going to give them something back at some point - especially with the energy efficiency stuff - to start getting people to see the health benefits, getting people to see that their house is better than the guy next door who didn't do it, that's the key. (RC SM3)

A similar situation existed for willingness to pay. Occasionally it was an opportunity to achieve a higher standard product, but more commonly it was a barrier that reduced client demand for sustainable products. As this interviewee stated,

> [If] 'Mum and Dad' (investors) say they actually want a greener product, or a more sustainable product, or one that responds to climate change, the market's going to say, "well that's an optional extra" and they won't pay. (NRC SM5)

If the client had a low level of understanding of or was sceptical about climate change, this too was seen as a barrier. However, if awareness of climate change had been developed through exposure to other information or case studies, it could positively influence client demand thus creating opportunities. As this interviewee stated,

> … if a customer hears or learns about an issue elsewhere in the world, they will be coming to the builder to say, "well, what's the solution to achieve this in my new home?" so there's a huge opportunity there for the industry to be able to provide solutions. (RC CM2).

While client demand for actions to address climate change was low in the residential sector, it appeared to be more common within the non-residential construction industry. For example, the interviewee from the industry association that supports the non-residential construction sector noted that large clients (including large banks) recognised that investing in the construction of, and then becoming tenants in a green building was a 'good thing to do' (NRC IA1), possibly for the reputation it earned them. The findings reported are in line with existing literature which finds that if industries believe their clients or the community are disinterested in climate change, they will not take action [34,37,43].

6.6. Other barriers

Numerous other barriers were identified in addition to the five discussed in depth above, complementing the above discussion. Firstly, a strong culture of corporate responsibility was considered by some interviewees to be beneficial for delivering projects that went beyond the minimum standards, as was corporate direction which had incorporated high standards for sustainability. This could help facilitate further actions in the sector. For example, as this interviewee explains in answer to a question on why he felt his company was doing more to address climate change than most others,

> Well it comes from the top down and the directors I think had great vision. [They] have … a very strong … corporate social responsibility … program running. They really value sustainability as well, so it's been a really good match. (RC SM2)

This is in line with work that found organisational culture can foster adaptation actions in the UK [46]. In other cases, leadership on action to address climate change from within the industry was felt to be inadequate because it was 'only the tier one organisations that could afford to have sustainability as a function in the organisation' (NRC CM3). This response was from a construction manager based in a small construction firm who did not have the capacity to employ a sustainability equivalent manager.

Training and professional development was another area that several interviewees felt was inadequate. One interviewee suggested that tertiary education typically was not providing graduates with the skills to lead climate change adaptation and mitigation in the construction industry,

> I think you've got to completely shift your thinking. And I would say that's not common. It's not a common ability for our industry to have. We tend to hang around with our own. We employ out of … the same universities. And again, the universities are training their people in the same way. (NRC CM2)

While some interviewees noted an improvement in awareness within the industry, this had not always translated into increased expertise. In some cases for example, industry workers were expected to be able to assess projects for their performance against voluntary standards without adequate training. In other cases, interviewees were concerned that improved awareness wasn't being translated into higher quality products due to a combination of lack of demand and a level of skill and confidence amongst industry members' that was insufficient to advocate for high quality climate change-responsive products. Interviewees observed that even when opportunities to update skills were made available, the culture of building and construction was not conducive to changing the industry in a way that would increase its ability to adapt to climate change in a timely manner.

6.7. Further discussion – improving the construction industry's ability to address climate change by 'activating' the regulatory framework

As discussed above, regulation was frequently identified by respondents as both a barrier and an opportunity to the industry's capacity to respond to climate change. This led to a deeper exploration of the regulatory framework that underpins the industry, which in turn led to the identification of several aspects of the regulatory framework that may be limiting the construction industry's ability to responsively adapt to climate change These are discussed in depth here.

The first of these is the complexity of the legislation, codes and standards, and their limited accessibility. As discussed in section 2, there are several documents that members of the industry must be familiar with, yet for many, their ordering and interpretation is likely to be challenging to follow. For example, although all relevant legislation and subordinate legislation is available for free via austlii.edu.au, it is not gathered into one package as it is in the ANSTAT package 'SE-1444', which is only available from SAI Global via a $400 subscription [23]. Similarly, the Australian Standards to which the BCA refers are also not freely available, with for example, the AS/NZS 3500.3:2015 (Plumbing and drainage, Stormwater drainage) costing $312 (also via SAI Global).

Principles of interoperability (the ability of diverse systems and organisations to work together [56]) suggest that 'no citizen or company should be forced or encouraged to use a particular company's technology to access government information' [[57], p.6]. Similarly, Fitzgerald and Pappalardo [58] state that democratic access to legislated requirements is only achievable if standards are 'open', i.e. freely available and easily understandable. Conversely, if government information is published in formats that impose licensing obligations on users, the information can no longer be regarded as openly available to the public, thus failing the 'interoperability ideal' [58].

The second limitation is that climate change is not explicitly recognised in the regulatory framework that governs the construction industry. As described above, the centrepiece of the framework, the NCC, is where provisions (e.g. standards) requiring buildings to be designed and built to resist the various relevant impacts are (or should)

be referenced. Currently, several physical weather-related phenomena that may be exacerbated by climate change are included [11]. One example is AS/NZS 3500.3:2015 'Plumbing and drainage, Stormwater drainage' [21,59]. Examples of other standards that are relevant to the building industry's response to climate change, but are not explicitly referenced in the NCC, are AS 5334-2013 *Climate change adaptation for settlements and infrastructure*; *a risk based approach* which provides general principles of adaptation and resilience [60], and AS 4055-2012 *Wind loads for housing*, the objective of which is to "provide designers, builders and manufacturers of building products with a range of wind speed classes that can be used to design and specify such products for use in housing" [61]. Despite their relevance, these standards rarely mention climate change and there is a concern that they do not incorporate a consideration of the most recent projected climate change scenarios. This suggests that the BCA needs to be subject to more active review for its adequacy to address the current and likely future impacts of climate change.

The third limitation relates to the process and time required to update the Building Code. For example, the ABCB is currently working on 2016/2017 changes to the NCC, scheduled for inclusion in a year 2022 update. Similarly, in regard to updating standards, while anyone can propose to Standards Australia that a product should conform to a new or revised standard, such proposals must 1) demonstrate the need for the change, 2) define the scope of what is to be included in the standard, 3) articulate the positive impacts, the negative impacts and the net benefit, and 4) provide evidence as to how the change will affect stakeholders [62]. This enables those outside the construction industry to propose a new standard, provided such a need is recognised and acted upon. However, it is not clear how decisions as to the standards that are explicitly included in the NCC are made. Specifically, if no single agency with appropriate climate change experience is tasked with identifying omissions from the NCC using a 'climate change lens', there is a high risk that opportunities to increase the industry's ability to respond to climate change would be missed during reviews.

As an illustration of this, a 2010 report by the ABCB found that 'buildings designed and constructed in accordance with the then current BCA were likely to be reasonably adequate for climate related hazards associated with a low emissions scenario' (i.e. up to 2060). However, 'if the climate were to change in accordance with high emissions scenarios', the current BCA was 'likely to be deficient in some areas' [63]. Subsequently, the ABCB acknowledged that,

> In order to better assess the future impacts of extreme weather events on buildings and plumbing systems, ongoing access to contemporary climate information including research and data is imperative. Additional research and more reliable data is required on specific climate impacts, such as cyclonic events, bushfires and intense rainfall, to ensure that standards can be adequately reviewed to take account of longer term trends ([64] p.37)

It went on to state that it was not the appropriate organisation to conduct such activities. Given more recent climate change predictions [65], it appears regular review and updating of the NCC by a range of experts, including those outside the industry, and with reference to the latest climate scenarios, will be important for ensuring the regulatory framework enables the industry to be responsive to a rapidly changing climate.

7. Conclusions

This paper provides new and important information, supported by empirical evidence, about barriers to climate change adaptation in the Australian construction industry. The structural operation of the construction industry is comparable to other countries; consequently, the barriers and opportunities identified in the Australia sector could provide insights for others in meeting the challenges of climate change. Opportunities to address climate change in the Australian construction industry were identified, including through the availability of information, and the sharing information about new processes and products both within the industry, and to the general public. Barriers to adaptation in the built environment sector identified in existing literature, were found to exist in the Australian construction industry context (i.e. regulatory framework, affordability of initiatives, awareness and perceptions, client demand). Additionally, new barriers have been identified, including barriers surrounding the language and terminology used to discuss climate change initiatives.

Regulation (e.g. the NCC) was a key issue raised in the study. It was seen as both a barrier to climate change adaptation, and as having potential to be an opportunity. Key limitations in the construction industry's current regulatory environment's ability to address climate change adaptation were identified including: 1) the complexity of the current regulatory framework, and the limitations to access; 2) climate change is not explicitly addressed in the regulatory framework; and 3) the length of time for regulatory reform to be implemented, the way in which change is enabled.

The study found that the construction industry has limited potential to act on climate change given its position in the building supply chain. The construction industry largely builds structures that another supply chain stakeholder has designed, and yet another pays for. This is a fundamental limitation on the sector. If the client is building the project for themselves there will be a vested long term interest in addressing all risks including climate change. However, in most cases builders are building for others. Hence, their focus is short term: largely minimising their risks and maximising their profits. While there was evidence that some companies do value climate change adaptation and mitigation and incorporate actions into projects, being a responsible corporate citizen is largely not valued in the sector which has a focus on minimising project costs given the high competition. With a lack of regulation to address climate change being imposed on the client, climate change is largely ignored, because it is not in their financial interest to think long term – despite the scientific evidence for the imperative to act on climate change risks.

Hence, a key recommendation arising from this work is that the National Construction Code and associated standards need to be reviewed and strengthened to ensure climate change adaptation and mitigation are addressed and incorporated. A comprehensive review of the NCC, to identify which aspects will be impacted by climate change be required to be undertaken. Additionally, a regime of more frequent updating and the shortening of time periods over which the standards must be enacted is necessary. It is important that regular updates occur in a manner which addresses the full extent of climate change anticipated, in line with Australia's current greenhouse gas emissions trajectory, which indicates international targets will not be reached [66]. It is recommended that this review is undertaken as a matter of urgency, and that resources are provided to expedite this process.

While addressing the three limitations identified here would be beneficial, it is likely that there are other issues that also limit the industry's capacity to respond to climate change. It would therefore be beneficial to comprehensively assess and address these across the construction industry and in the context of the whole suite of built environment sectors – the built environment supply chain, and a full range of actors including clients and their advisors. It would be beneficial for this work to include both qualitative and quantitative research methods.

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